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FUEL ETHANOL PLANT
NEAR AMSTERDAM, MONTANA

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FUEL ETHANOL PLANT NEAR AMSTERDAM, MONTANA

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COMPANY HISTORY

As of August 25, 1980 A.E. Montana was a corporation, but had not begun construction of a plant. Company directors had formulated plans to secure financing and had been working towards bringing these plans to fruition.

Ethanol production across the country was emerging as an attractive alternative energy source. Government programs involving large sums of money in addition to loan guarantee arrangements seemed to indicate financing would be available. As these government programs were investigated by company management, it slowly became apparent that guidelines were unclear regarding loan qualification, application and actual issuance. This seemed especially true for the Farmers Home program. Individuals in that government agency with limited backgrounds in the ethanol field were asked to pass judgement on ethanol plant feasibility studies, engineering plans and projections. Other companies experienced waiting periods over 18 months just to receive negative responses based on what they considered inaccurate evaluative procedures by that agency. Still other companies received no formal commitments, negative or positive, and were simply kept waiting. Finally, the few companies that received approval waited, in some cases they are still waiting, for the actual financing.

A.E. Montana management looked into applying for financing through the Farmers Home, but based on the timing involved, in addition to the other above mentioned factors, decided against an attempt to work through that program.

Through the month of September over $120,000 in venture capitol and other assets including ground and a vehicle were committed to the corporation. Through July, August and September, grant applications had been prepared. Preliminary indications were that favorable responses could be expected from the two state agencies involved, the State of Montana, Department of Natural Resources, and the State Department of Agriculture. The Department of Agriculture did approve a grant to A.E. Montana for $7,500.00 in October and the D.N.R.C. approved a grant to the company for $75,000.00 in December. The Department of Agriculture grant is to be repaid after three years, while the D.N.R.C. issued a direct grant, not to be repaid, to financially assist the company in building a demonstration ethanol plant facility. The Department of Agriculture money was issued almost immediately, while the D.N.R.C. money was issued intermittently over the course of plant construction. The last ten percent of this grant is still pending completion of this report.

A.E. Montana management felt that with the total of over $200,000 that had been raised or committed in the fall of 1980, a complete long term financing package could probably be procured through local banks and the S.B.A. loan guarantee program.

In September a final choice had been made regarding the ethanol system to build. Schroder Farms, of Campo, Colorado, had built a system that had been operational for 24 months, and they were producing anhydrous ethanol. Company personnel which included a mechanical engineer, visited the Schroder plant and reviewed their entire process. Other systems had also been considered, but none offered the same combination of relatively low cost and proven performance. Schroders were not actually selling ethanol plants. They provided flow charts, and sold distillation columns and dehydrators, in addition to drying technology for processing distillers wet grains. On this basis, plants could be constructed using local labor and materials, resulting in lower plant construction costs.

Construction actually began early in September based on the premise long term financing could be negotiated and concluded within six months.

Local banks were approached with the projections, plans, and financial sheets. It would take cooperation from both the S.B.A. and a bank, and of course, the company, to make the loan materialize.

Through the course of the next several months, it became apparent the cooperation would not materialize. The S.B.A. had guaranteed a loan for another plant in Laota, Kansas and was hesitating to become involved in another ethanol facility until a working history was developed on the Kansas plant. Coincidentally, the ethanol plant in Laota was another Schroder plant.

Kansas also offers a state tax differential for gasohol, but is is different from Montana;s in that the ethanol does not have to be in-state produced. Accordingly, the Laota plant was competing with the Midwest Solvents plant, located in Atchison, Kansas, and the Archer Daniels Midland plant of Decatur, Illinois, along with several smaller regional plants.

All this competition added up to marketing difficulties for the Laota plant. At the time A.E. Montana was applying for an S.B.A. guaranty the Laota plant was at maximum inventory capacity. Thus, as the test case for S.B.A., the Laota system worked well enough, but did not appear able to sell its product. These inventory difficulties continued through the fall but at this time, as the gasohol market has had time to develop, the Laota plant is moving its production steadily.

Since S.B.A. hesitated, the bank the company was dealing with at the time more or less dropped the package. The whole concept seemed far too unproven for a bank to be involved with. In addition, the net worths of the directors was not large enough to cover the banks risk, in the bank's opinion.

It became apparent that a company stock dilution would have to take place. New investment money would have to be attracted into the company. Then perhaps a long term financing package could be negotiated from a position of strength.

Sales of stock are regulated by the State Securities Commissioner. State law regulates the number of people that can be solicited to purchase unregistered stock. State law also regulates the number of stockholders in a Sub. Chapter S. corporation. This corporation structure was opted for because it allowed stockholders to individually earn the tax credits associated with energy production.

So, working within these limitations, company management raised an additional $200,000. Since only ten solicitations were allowed by state law for sale of an unregistered stock, the process of becoming registered was initiated in late January. Legal counsel had indicated a processing period of six weeks should be sufficient to become registered. Once registeration was complete any number of Montana residents could be solicited.

Plant construction had been delayed through January of 1981 pending the securing of additional financial commitments. One of the original incorporators had altered his investment commitment, investing less than the amount expected. Other investors however had materialized. Land-owners, agriculturally based, were in position to borrow money from the Federal Land Bank at lower than conventional interest rates, and over a long term. Investors were traded company stock for this type loan. In some cases conventional venture capital was also invested on this basis. It was in this manner that the above mentioned capital was raised through late winter and spring of 1981.

The timetable given the company regarding Security Commission clearance was inaccurate. In fact, it took six months to finalize this clearance procedure. This resulted in a period of two and one half months when additional investors could not be solicited within the Security Commission guidelines. This delay affected the startup timetable in that cash necessary to continue construction was not forthcoming. Consideration was given to hiring new legal counsel, but repeated indications that the process was nearly complete argued against such a move. Admittedly, a delay of three weeks was the fault of company management. This amounted to a delayed response time to the Helena lawyers request for additional information. But overall, the completion of the Security Commission clearance and stock registration was not handled in a satisfactory manner. The resulting prospectus contains numerous mis-statements and errors and it remains the intention of company arrangement to have the prospectus updated and corrected.

The physical plant was estimated to cost a total of $475,000 to build. Estimates from the Schroder people ran about 10% lower than this figure. As the facility was developing, however, certain design improvements were opted for. For instance, circuitry to control the system from a centralized point together with a quality control sensory system throughout the plant were included. Materials and equipment was a relatively small percentage of the expense associated with this technology. Time and labor represented the larger expense. Since the company was working with a stock option plan, intense technical and professional labor could be afforded, whereas, materials expense was more difficult to deal with. All additions were viewed with these circumstances in mind.

By the time the Security Commission clearance had come through in July, the plant was nearly completed. In many cases, arrangements had been made with suppliers for deferred payments. Especially on the larger purchases, suppliers were able to extend a payment period. Two additional investors came in for a total of $63,000 and one of the earlier investors contributed grain for additional stock. An independant contractor was late with the boiler installation but otherwise construction was nearly complete.

START UP

The company processed its first batch of white wheat in late July of 1981. Although the plant was not entirely in place at the time, the dehydration system had not yet been installed, it was capable of producing 190° ethanol. In early September, the molecular sieve-dehydrator was installed and anhydrous, 200° was produced. Through the balance of September and into October and November, the plant operated consistently, except for one point around mid-October when the entire plant, except for the dehydration system, was down pending agitator shaft replacement. This took about twelve days.

Agitator performance and dependability was a major start up problem. The company's mechanical engineer had designed the agitators using discarded drill stem for the shafts. It was not strong enough. In addition, the blades had a tendency to slip on the shaft. There were nine separate disruptions related to agitator breakdown, prior to the redesign work in October. During the redesign period the shafts were replaced with high-strength steel shafting. Since then, two minor disruptions have occured, one slippage and one paddle bracing wear off.

Other problems resulted in bottlenecking the plant. These included plugging in the grain system, packed flour in the weigh bin, steam generation in the bioler, and column output. Another problem was cash shortages resulting in an inability to inventory enough grain to prevent operators from having to sweep out bins, manually. All these difficulties and others normally associated with startup of a new system, were compounded by a separate development, the formation of hydrogen. In two instances bacteria, a form of the

Claustridia genus, formed explosive quantities of hydrogen gas.

The first explosion opened the top of a batch tank. Neither the tank's agitator nor motor was harmed, but conduit above the tank and some plumbing had to be replaced. The tank top itself was re-straightened and welded back in place.

The presence of bacteria in the system was no surprise. It is a fact every ethanol plant has to contend with. But it was something of a surprise that we were dealing with a bacteria capable of generating enough hydrogen to explode, even with the venting on each tank. These circumstances were so unusual that Professor Pete Gras of MSU, when given the data surrounding the first explosion, ruled out the possibility of hydrogen.

After reviewing the circumstances surrounding the first hydrogen incident, the conclusion of qualified company personnel was that we were dealing with bacteria producing gases. A number of measures were taken to prevent a similar experience. These included speeding up the grain-flour feed time, giving the bacteria less time to populate the mix; keeping the agitators on during low temperature periods to promote venting and the initiation of design work on a CO_2 flooding system.

Since company personnel were not absolutely sure of the gas we were dealing with and the properties of the potential gases differ somewhat, the CO_2 flooding remained an option pending final resolution of the question. The final step in dealing with the gas generation was in upgrading the company's lab to include equipment to analyze data sooner and more expeditiously.

The second explosion verified the company microbiologist's guess. Samples taken shortly after the incident proved we were dealing with hydrogen. The steps we were taking had been in the right direction, but a bottleneck in our grain system had given the bacteria enough time to generate explosive quantities of hydrogen.

In the first case the tank temperature had been 88 degrees. The second incident occurred at 125 degrees. Since the bacteria had demonstrated their ability to generate at 125 degrees, grain was no longer added in this temperature range. The second explosion had opened the top of a tank, damaged some plumbing, and knocked some foundation cement off the six foot building sidewalls. More significantly, it had split open the grain leg feeding into the tank.

Corrective measures were taken that included replacing the leg with a system designed to discourage sparks. This system had plastic cups instead of metal. As already mentioned, grain was added at 160 degrees or hotter, even though this hampered the effectiveness of an enzyme critical to our formula. In addition, a vapor sensor system design was initiated.

As backups, penicillin and sodium bisulfate were inventoried as bacteria inhibitors. These are chemicals that will not carry through the system to adversely affect the stillage byproduct. A final step was to ventilate with a portable fan system, in any situation where gases may be formed.

In addition to these corrective measures, a caustic spray system to sterilize between batches was considered. At this time indications are that this system will be installed to further safeguard against bacteria carryover between batches. An additional rinse cycle using phosphoric acid may also be implemented.

Both explosions were covered by insurance, but the $5,000 deductible on the company policy represents a loss.

Through these difficulties A.E. Montana continues production. While September projected production was exceeded, both October's and November's were not. Fortunately, the market for ethanol has kept pace with the company's production. A total of 46,000 gallons has been shipped from A.E. Montana to date. Demand has increased in conjunction with A.E. Montana's production of alcohol.

At this time a market for 30,000 gallons of ethanol per month has been established. The dealers who represent this demand have indicated a good potential for doubling this rate. In other words, A.E. Montana's full scale production rate of 60,000 gallons per month could be marketed within the market area already developed.

During October another ethanol plant came on line in the state. At full scale production this system will produce three times the output of A.E. Montana.

This outfit, Alcotech of Ringling, Montana, has worked with A.E. Montana management in developing the ethanol concept in the state of Montana. Both companies are named in a grant intended to help the Montana public and gasoline jobbers and retailers become aware of the characteristics and qualities of ethanol. This grant has been submitted through the Montana Department of Natural Resources and Conservation educational program. In addition, both companies have worked at developing markets in the states major urban centers, as well as smaller, more ag-orientated communities. Results of these efforts have indicated that with adequate promotional work the market readily accepts the ethanol concept.

A problem may very well develop however, if the appropriate promotional work does not coincide with the increase in ethanol production happening in Montana. A.E. Montana is well on the way to securing an adequate market for its production but the market needs to expand to take in additional ethanol from the Ringling facility. Experience of other states where the ethanol concept has developed indicates Montana's production, with both plants at full swing, will represent only a fraction of the potential sales of gasohol and/or other ethanol combinations. The market needs to evolve at the same rate as ethanol is produced in the state. If the rate is slower either or both companies may experience cash flow difficulties. It is the position of A.E. Montana management that market development is indeed of critical concern, since cash flow difficulties can not be tolerated in the company's present cash-poor condition. Long term financing would alleviate this condition, but market development would still require time, attention and capital on the part of the company.

Research into marketing of manufactured items using ethanol as a base material is an exciting prospect. An effort to develop forumlas for such items has been undertaken by A.E. Montana. Two other ethanol systems have joined A.E. Montana in this research and development phase. With the capital raised by the company and these other systems tentative formulas have already been developed.

A doctor of chemistry has directed the research out of a college in Kalamazoo, Michigan. The chemist will be returning in December of this year to continue research work in Bozeman. Indications are that a finished formula for windshield washer solvent has been completed and that an additional formula for solid sterno is nearly complete.

A.E. Montana, in conjunction with the Phil Tatej Plant of Geraldine, Montana, has applied for a grant from the Private Industry Council of Montana to construct a research facility in the Gallatin valley, Response from the other participating ethanol plant, the Schroder system of Campo, Colorado, indicates they are strongly in favor of expanding research capacity. Preliminary research work indicated there are literally hundreds of manufactured items in which ethanol or some other form of alcohol that ethanol may be a suitable replacement for, are on the market in this country now. Results of this research work could very well dramatically expand the demand for grain alcohol. This work could also result in substantial increases in profits for ethanol plants. A.E. Montana seems to be one of the few ethanol plants that have initiated a research program to consider such alternative marketing concepts. It is company management's intention to capitalize on developments in this research area.

The two ethanol systems that are participating in the research effort along with A.E. Montana have negotiated participation fees with the company which entitles them to participate in the research results. A format in which fair and equitable participation can take place has been tentatively drafted and should be concluded at a meeting between the three systems in March of 1982. A.E. Montana controls the disbursal of funds and research direction and will continue to manage the research effort, though other ethanol systems may be offered participation research results at some point in the future.

Other areas of interest to the company besides the production of manufactured items using ethanol as a base material include continuous cooking and fermentation to speed up process time, gluten removal and processing, drying of distillers wet grains and solubles, conversion of cheese whey and cull potatoes, and hydrogen and/or methane production.

Process efficiency improvements may also be considered in the areas of grain analysis, heat generation via combustion of sawdust and other forms of biomass, and use of grain as sieve material.

Other areas of consideration include use of distillers grains and solubles as a base for pet food production and a hydroponics syster system taking advantage of waste hot water and CO_2.

But before any of these innovations take place the existing system must operate consistently, and optimize both production and efficiency. It is estimated that given nine months and adequate financing optimization of the present system can be achieved. However, in the event funds to develop in any of these other areas become available beforehand, action will certainly be initiated to bring about process improvements, increased efficiency, or new product lines, with the end goal being increased production and profits.

COLUMNS AND DEHYDRATOR

The company purchased a 24" diameter stripper column along with two 18" columns, one a rectifier and the other a finish column. The columns are sieve tray design.

Performance has not yet been optimized on the columns. The take off of fusel oils has complicated operation. The takeoff valves provided by Schroders were not sufficient, and pressure buildups resulted in the rectifier column. Additional valves have been installed and the situation appears to have been alleviated.

Since barley processing was begun in November another problem has developed in the columns. Barley hulls tend to collect in the downcomer spout in the stripper column. These hulls block the incoming beer, bottlenecking the system.

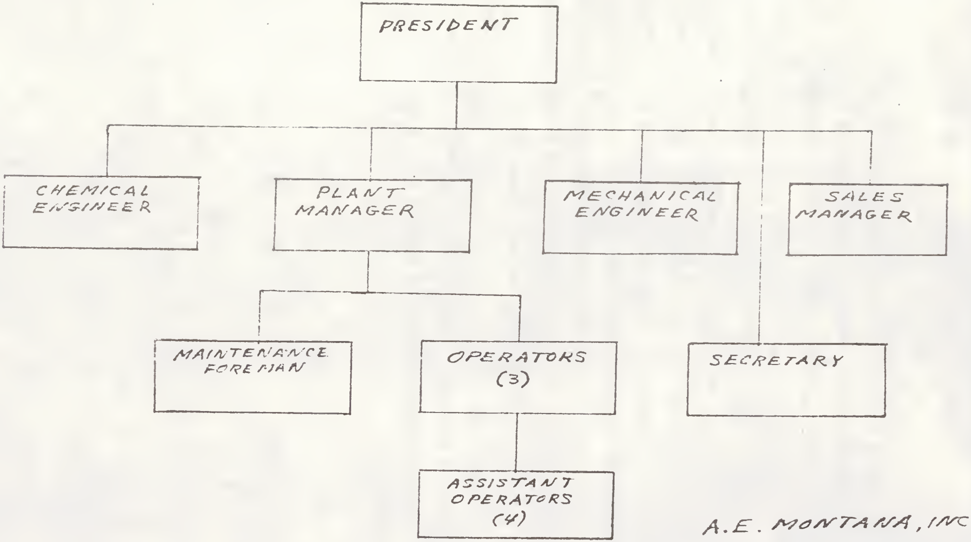
There are several alternative solutions to this development. A hammermill could be used in place of a roller mill, reducing the hulls to powder consistency. This would probably solve the problem, but may result in a troublesome beer viscosity. The company is keeping in touch with several other systems using barley and hammermills to see what they experience in this area.

Another interesting solution is removing hulls from the barley, either with a pearler before milling or from the flour after milling. Indications are that hulls along with 2-4% of kernel would be removed with a conventional pearler setup. Use of a screen separator in removing hulls from the flour would result in similar percentage of kernel loss, probably slightly higher. The technology to remove hulls from flour could be quickly adapted into the system using technology already present. Pearler technology, on the other hand, would take an estimated four to five months to deliver.

An advantage to dealing with hulless barley is that less mass would be pushed through the system. Plugging and viscosity difficulties would be alleviated while alcohol percentages in the beer could be increased, resulting in an overall increase in system efficiency.

The dehydrator system has operated satisfactorily since it was turned on in September. Molecular sieve pellets were purchased through Grace Chemical. Life of these pellets was projected by Grace to be about 2,000 cycles, although contamination could shorten this considerably. Each cycle turns out about 1500 gallons of anhydrous currently, and the dehydrator is capable of almost two cycles a day.

Contamination may be occuring to some extent. Fusel oils may be pushed through the columns on occasion although with the present valve system this should not happen. Other agents, probably organic acids, may also get through. A procedure to test for possible contaminating agents on a regular basis is another desirable goal. Testing can be completed at this time using the nearby University facilities.



A.E. MONTANA, INC.

ORGANIZATIONAL CHART

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TANK DESIGN AND CONSTRUCTION

Original design requirement for the A.E. Montana alcohol plant called for two cone-bottomed tanks, one for cooking and one for sacrification. Also needed would be four fermenters and hot and warm water storage tanks. The cone-bottoms in the two tanks would be to facilitate drainage of the thicker material that had not yet been fermented. A local steel supplier was contacted and material was ordered for the above tanks.

The cone-bottom tanks would consist of ¼ inch carbon steel plate for the first 8 feet rolled to a 20 foot diameter. Two additional 6' rings of 3/16 steel plate would complete the body of the tank. A flat 3/16" steel top would be installed on the completed rings. Two support beams of 4" x 8" rectangular tube were placed across the tank six feet apart under the lid. These beams would carry the agitator motor and gearbox. The cone-bottom would consist of preshaped pieces of 5.16" steel welded inside of the bottom ring with a 2 foot rise from the center to the outside of the ring. The sides of the tanks would rest on ½" steel plate 8 inches wide cut into a circle with a 9"8" radius. All pieces would be welded together inside and out.

The fermenters and water tanks would be similarly constructed with 3/16" steel for the bottom ring instead of ¼" and with a 3/16" flat steel bottom.

During further design work it was determined to maintain the mash in each tank throughout the various phases of the production process. At this point the initial order was canceled but since some of the special pieces (the pie shaped and 8" ring pieces) had already been cut, A.E. Montana had to accept delivery of them. They have since provided a stockpile of 5/16" and ½" steel for other uses. Some has also been sold to other individuals.

New bids for steel were received and the purchase bid was awarded to Northland Steel of Billings with a definite delivery date stated. The needed material arrived over a week late.

The tanks would be constructed with interior cooling coils installed and tank design would be changed accordingly. The number of tanks required would also be fewer. The new design called for three "Batch" tanks with interior cooling coils and flat bottoms. Additionally, a half size (25,000) gallon hot water tank and 47,000 gallon warm water tank were required. These tanks were constructed of 3/16" carbon steel throughout with flat tops and bottoms. Two foot by 3 foot access doors were provided at the bottom of each tank. Additional structural support of ¼" x 2" angle iron was provided on the top to avoid sagging and to facilitate construction. The batch tanks were 47,000 gallon capacity, 20 feet high and 20 feet in diameter. Each had a ¼" carbon steel bottom ring 8 ft. high and two additional 6 foot rings of 3/16" carbon steel. Support beams of 4" x 8" rectangular tube were placed 6 feet apart under the lid on top to support the agitator assembly. A bottom access port approximately 2 feet by 3 feet was provided and an additional top lid approximately 20 inches square would allow inspection and material addition while the tank was loaded. Cooling was accomplished by 3" schedule forty steel pipe rolled to an 18 foot diameter and installed inside the batch tanks. Six vertical fins 16 inches wide were placed symetrically around the tank and the cooling coils notched and fastened into these fins. The coils were placed 12 inches apart and 750 linear feet of 3 inch pipe was installed in each tank. Cooling water entered each coil from the bottom and exited at the top where it went to storage or disposal areas.

Since we planned to build our own tanks inside the building a special overhead crane was built and a 2 ton electric hoist purchased to lift the sheets of steel into place. Using a rubber tired front and loader and this hoist to handle the large sheets greatly facilitated construction. Different techniques of construction were suggested by our steel supplier Northland Steel in Billings and by other knowledgible persons. A.E. Montana personnel developed many of their own techniques. Four welding machines were employed during the actual tank assembly and a crew of eight persons worked on construction. Cooling coils were installed by one 3 man crew while the warm water and hot water tank were being built. Construction proceeded at a good rate and the last tanks went together much quicker than the first one.

Each batch tank would require an agitator to mix and circulate the material inside. Based on data from Schroder Farms the agitator would require a 40 HP electric motor and corresponding gear reduction unit to reduce the agitator speed to approximately 40 rpm. Four sets of blades would be required on a central shaft. The shaft would be of 4" steel. After consulting with Schroder and making the appropriate calculations, A.E. Montana decided to use hollow seamless tubing with ½ inch wall thickness and a 4 inch outside diameter. Before an order was completed for this tubing Schroders suggested using rotory drill stem for the agitator shafts. Again calculations were made based on new drill stem data and a correction factor of ½ was used for the used drill stem. A safety factor of three times the acceptable stress was still obtained. It was decided to use used drill stem at a savings of approximately $900 over the seamless tubing. The agitator blades were constructed with used 3 foot long grader blades being welded at a 45 degree angle to split clamp-on type hub. Gussets were welded to the blades undersides for additional support. Three of the blades in each tank were of the above simple design while the fourth blade had to be designed to sweep the heavier material off the floor of the tank.

The bottom of the agitator shaft was supported by a babbit bushing the top of which was about 20 inches off the floor. The bottom blade was designed to clamp to the shaft above the bottom bearing support, clear the support structure, and still sweep within six inches of the bottom of the tank. These blades were constructed of angled grader blades and reinforced and gusseted with steel.

The shaft, Browning shaft mount gear reducer, and blades were supported with a naither double roll taper bearing mounted on two 6 foot long 4" x 8" rectangular tubes placed crosswise to the longer 4" x 8" tubes beneath the lid. A 40 HP electric motor was also mounted on these tubes. Construction of the tanks was begun on 3/10/81 and completed on 7/20/81 with agitators being installed by 7/25/81. With the completion of other systems a batch was run on 7/26/81.

As further batches were run it became obvious that drill stem had not been a good choice for agitator shafts. Shafts in both tanks 1 and 3 twisted off causing poor mixing and cooling problems as well as making it very difficult to clear the tanks. New 4" stressproof steel shafts were finally ordered and installed in October and seem to be working fine. Problems were also encountered with the bottom blades with two of them breaking off. All steel blades are being constructed of a simpler design and it is hoped these will be more adequate. New drill stem might have been a good choice for the agitator shafts, but used were definitely not due to accumulated stress and fatigue and inadequate stiffness. Grader blades were sufficient for the simpler blades but were too brittle, especially when welded on, for the structural requirements of the lower blades. All blades are currently modified to the classic angled paddle design with a 16" square of steel mounted 28" to the center from the shaft and at a 45° angle to the horizontal. The blade rotation is currently pushing the material down in the middle of the tank and appears to be giving adequate agitation except during grain addition. Further vertical adjustment of the existing blades should solve this problem.

Each batch tank has attached to it a 2" fill line, 6" grain addition tube, 8" vent tube to the outside, 4½ inch lines for enzyme and chemical addition and 2" cooling water inlet and outlet lines. In addition, each batch tank has a 4" flanged grain opening at the lowest point near the central trench. Temperature and high and low level alarm probes are also attached. The tanks will be primed and painted in the future on the outside only. The hot water tank will also be insulated to conserve the energy in the hot water.

BOILER

One of the major factors to be considered when constructing an alcohol plant is a source of heat for cooking, distilling and dehydrating. There are many factors involved in selecting this heat source, cost of fuel, cost of converting fuel to heat, availability of fuel and of conversion equipment, and applicability of fuel to the particular heating task.

Some of the fuel tupes available in the area of the A.E. Montana plant are natural gas, electricity, coal, wood waste, and agricultural wastes. Solar energy is also plentiful, but would be far too costly to implement at present technological levels and for a plant of this size. Natural gas was selected initially as being the cheapest available fuel and requiring the least expensive conversion equipment. The dehydration step would be a simple burner to heat the air which would dry the sieve material. The cooking and distilling steps would require conversion of this fuel to steam. Based on Schroder Brothers experience, it appeared that low-pressure steam would be a choice for the cooking and distillation stages.

Coal had been considered as a possible fuel for the boiler in the early stages of design but since the boiler cost and associated supply problems were prohibitive, natural gas was selected as most appropriate.

Some local plumbing suppliers were contacted concerning supplying A.E. Montana with a natural gas fired low pressure boiler. We had determined that approximately 100 horsepower would be necessary for the cooking and distillation steps as both would be running at the same time. Correspondence and phone conversations were initiated through Amfac Supply in Bozeman with a supplier of Columbia boilers in Denver, Colorado. They proposed supplying a 100 HP natural gas fired boiler. Work was progressing on the plant site and building at this time and final design needs for the boiler were not ready yet, so an order wasn't placed.

Design of the steam delivery lines was completed by December. A four inch steel header would be necessary to supply adequate steam to the batch tanks and the distillation columns. Steam would be injected at three points around each batch tank with quarter turn ball valves controlling each steam injection point.
The steam would enter through 2" steel lines, be reduced to 1½" and finally, dispersed through a tee shaped four foot long section of 1½" pipe capped on each end and with 3/8" holes drilled every

6" along the pipe. This dispersion was necessary to avoid the slamming and banging of the steam as it expanded in the liquid of the tank. The entire header and all the injection lines were to be slopped away from the boiler to allow collection and drainage of the condensate from the lines. After the third tank the steam header would be reduced to 3" in size. A thermally controlled condendate removal trap would be placed prior to the control devices for the columns.

The distillation columns require a carefully regulated steam flow to avoid upsets in the distillation process. To obtain their regulated flow a control section was designed and installed ahead of the distillation columns.

This control section consisted of a fixed orifice in a straight section of 3" pipe with pressure taps on each side of the orifice. These taps were connected to a differential pressure cell which in turn controlled an electrically operated ball valve to regulate steam flow. As long as sufficient pressure was available to the valve a carefully regulated flow could always be maintained.

In April, 1981, Gallatin Enterprises, a local energy contractor, came to us with a proposal for a solid fuel boiler system. They were planning on marketing straw pellets in the near future and were attempting to provide a market for their product. They also were heating contractors and could provide the necessary boiler and associated equipment. Negotiations with them progressed and they were given our requirements for a boiler, mainly that we needed 100 usuable horsepower. Financial arrangements were made and settled on and a contract was drawn up with Gallatin Enterprises agreeing to supply a 135 HP Kewonee boiler, stoker, induced draft fan, stack, coal bin, and coal unloading conveyor and pit. A fly ash collector would be provided at extra cost if necessary. The boiler would be a double pass fire tube type boiler manufactured of steel. It would be safety tested and be provided with all necessary control and safety devices for continuous operation. Because of the coal unloading requirements and necessity for a masonary stack the boiler location was moved from its original site at the front of the building to the back corner of the building to take advantage of the grade difference at the rear of the building and to provide room for the coal unloading and storage area. This also simplified the steam header to the batch tanks and columns. The new boiler location required switching the warm water tank and the hot water tank which again proved to be advantagous from a plumbing standpoint.

When the order was placed for the boiler it was found that a 165 HP boiler was immediately available while a 135 HP boiler would entail a ten to twelve week delay. The 165HP boiler was ordered and was to be installed and operational by June 1. Work was begun on the coal bin, stack, and coal unloading area.

As the completion date drew near the boiler had arrived but the stoker was delayed. Since the stoker had to be installed before the boiler, progress slowed and finally halted with completion of the coal unloading and storage areas and stack.

In this interval, A.E. Montana consulted with Glen Fox with Fox Boiler of Butte for general advice on boiler operation and also for chemicals to treat the boiler feed water to avoid corrosion. Mor Fox suggested that the base of the boiler be extended vertically to provide more combustion space for the coal. At this point, the stoker had arrived and Gallatin Enterprises had begun installing the stoker and boiler base. It was determined that the extension of the base would be worth the expense and time and this was installed by A.E. Montana delaying the boiler installation by a couple of days.

The 30 inch high base was constructed of steel and lined with 3000° castable refactory material 4 inches thick. A fly ash pit was also constructed at the rear of the fire box area. Gallatin Enterprises then installed the boiler on the extended base and attached the flue pipe to the stack. The induced draft fan had not arrived at this time so an open pipe was run to the stack. A.E. Montana then attached the steam header. Mr. Fox also pointed out the need of a preheating and treating tank for the boiler feed water. A used stainless steel, 400 gallon insulated dairy tank was purchased from Fox Boiler to inject the pre-heated and chemically treated water into the boiler as required. The water also had to be softened so an industrial grade water softener had to be installed prior to the boiler treatment tank.

The boiler was fired for the first time in late July and everything seemed to work reasonably well. A small amount of non-stoker coal had been purchased for trials and it did not burn well but when stoker coal was obtained combustion improved. The boiler was still not producing rated horsepower, however. When the i.d. fan was finally installed at the end of September, efficiency improved but the boiler still appeared to be unable to produce a steady steam flow at high heating rates. When the distillation columns were in operation only 1 1/2 to 2 heating lines could be open to any tank and still maintain adequate boiler pressure. Pressure was regulated to remain between 10 and 12 psi but often dropped lower than 10 psi at high steam rates. A recent test by A.E. Montana personnel indicated that only 97 HP is available to us at this time.

Coal is presently being hauled from Roundup, Montana at the rate of $42.00 per ton. There are some energy savings and tax advantages to be had using coal, but a natural gas system is certainly less complicated and expensive to install and there is no problem with clinkers and ash removal and disposal- When straw pelleets become available A.E. Montana will consider burning them and is also currently looking into using sawdust and wood waste from the local lumber industry. One of the greatest advantages of the solid fuel boiler is its versatility and adaptability to other fuels.

It is highly recommended that anyone contemplating solid fuel heating systems for alcohol plants first contact knowledgeable, reputable suppliers and contractors and obtain complete plans and all available options for each plan before making a final decision on the heating system to be used. Also be prepared for a considerable time delay before completion of a solid fuel heating system as sup-liers are somewhat limited, as are knowledgeable installers.

INSTRUMENTATION AND CONTROL

The ethanol plant set up by A.E. Montana, Inc. incorporates various sensors for surveillance, warning and control. The conditions being monitored are as follows:

30 temperature
15 levels, including high and low levels
4 pressures (not including standard pressure gauges)
3 flows
4 motor loads (current sensors)
1 flamable vapor concentration
26 pilot lights showing that motors are on (equipment in operation)
2 weights: the truck scale and the ground grain weigh bin

Eight of these conditions are being automatically controlled, such as tank levels being used to turn pumps on and off, steam flow to the distillation columns, temperature and level controls on the columns, and quantity of water for a batch.

Thirty of these sensors are connected into the alarm system, which sounds several horns and flashes the appropriate red indicator light to alert the operator when an undesirable condition occurs. A second alarm system is provided on the dehydrator.

The boiler and dehydrator have their own controls which are not included in the above tabulation.

Control Panel

A 4 ft. x 3 ft. flow sheet is provided, on which process equipment and flows are shown, along with the location of the various sensors. Equipment "running lights" (in green), alarm points (in red), and miscellaneous indications (in yellow and white) are present on this panel. Alongside this flow sheet is a digital readout with multi-position switch for the various sensors. Also present are various dials for distillation column controls, and switches for the reagent pumps.

Provisions are made for the addition of a small computer to the system. This computer would receive input from the various sensors, compute temperatures and flows, control the process (particularly the columns), display the data on a CRT monitor, and periodically print out data.

The instrumentation and controls were designed and constructed by project personnel, using surplus and inexpensive components. This is in contrast to purchasing standard industrial instruments. The cost savings are estimated to be about $40,000. The design approach is illustrated by the following: The temperature sensors are inexpensive thermistors (temperature-sensitive resistors, about $.25 each), inserted in ½" diameter wells, the circuit voltage output is fed into the signal conditioner, where an amplifier with admustable zero and gain converts the signal into the standard 0 to 5 volts output. This output is then fed into a multiplexing section for input to a computer, and also to the digital readout and automatic control circuits.

The distillation column "take" (190 proof product) is controlled from the final mid-column temperature. When this temperature is higher than usual, the "take" automatic valve (constructed from a surplus aircraft 24 volt operator and a ½" ball valve) closes an appropriate amount, reducing the take and returning more reflux to the column. This tends to raise the alcohol concentration and lower the temperature.

Laboratory

The ethanol plant set up by A.E. Montana, Inc. is equipped with a laboratory for process control and experimental work. It is a 20 ft. x 15 ft. room, with 21 lineal feet of laboratory benches, safety shower, and auxiliary storage area.

Equipment includes a drying oven, analytical balance, triple beam balance, microscope, PH meter, and various equipment and glassware for small batches and distillations.

Plans for additional equipment include an agitated temperature-controlled bath with provisions for 6 to 8 separate flasks, for investigation of the effects of various variables such as grain type, time, temperature, catalyst level, etc.

Problems Encountered in the Fermentation of White Wheat and Barley to Ethanol

A. Lump Formation During Grain Addition

A major problem encountered during the addition of either milled white wheat or barley to water is the formation of varying sizes of lumps. This problem develops when between 30 and 50,000 pounds of milled grain has been added to 20-25,000 gallons of water. Grain over and above this amount tends to mix in poorly and form unhydrated lumps. These lumps vary in size ranging from less than one pound up to several thousand pounds. The most likely reason is that as grain is added the viscosity of the mixture increases and consequently the violent agitator blades are designed to pump liquid down in the center of the fermenter. The overall motion of the liquid is then a circulating motion with the liquid rising at the tank wall, pulled to the center, and pumped down. At higher viscosities this circulating motion is not observed. As a result of decreased mixing incoming milled grain is not hydrated and forms lumps.

Milled grain lumping leads to a variety of problems. Lumped grain results in starch being unavailable for enzymatic degradation, consequently, a loss in yield. Also, lumps carry through the system during distillation and plug lines resulting in a loss of time and alcohol. The most significant problem associated with grain lumping is the fact that unhydrated grain acts as an insulator during cooking and bacteria naturally present in the grain are not killed by the high cooking temperatures. After cooling of the mash some of the lumps break up releasing these bacteria into the medium causing an infection. These bacteria utilize the glucose produced by enzymatic breakdown of starch and thereby reduce the ethanol yield. Also, these contaminating bacteria produce end-products such as acetic, propionic, and lactic acid which result in a decrease in fermenter PH requiring addition of sodium hydroxide to adjust the PH in a more desirable range. These are also indications that some of these acids may carry over with the ethanol and produce corrosion in the molecular sieve dehydrator.

Barley is much worse than wheat with respect to increasing the viscosity of the beer due to a higher concentration of glucans in barley compared to white wheat. The thickening associated with the glucans can be controlled by the addition of an enzyme (beta-glucanase) which aids considerably in viscosity reduction. However, this enzyme is (according to the manufacturer) ineffective at temperatures above 130° F. Grain addition at this temperature is undesirable due to rapid growth of bacteria in the grain at 130° F. or less.

To reduce the problem of lumping several steps have been taken.

1. The grain addition spout has been moves so that grain is added

at the tips of the agitator blades. 2. The agitator blades size has been increased. 3. Cutter bars have been installed vertically between two agitator blades to mechanically break lumps. 4. A manufacture of beta glucanase active at temperatures of 160-170° F. has been located.

B. Foaming

Both barley and white wheat have a tendency to foam significantly at the boiling point. On occasion foaming has resulted in loss of material out the exhaust vent and man hole which not only reduces the volumn and consequently the yield but also produces an unsafe condition. When foaming occurs it can be controlled by addition of a silicone antifoaming agent and by stopping agitation for a period fo time.

C. Barley Hulls

Barley is ground whole, therefore, the hulls present carry into the fermentor. Hulls contain very little fermentable carbohydrate yet their weight must be accounted for when grain is added to a fermentor. But the primary problem caused by hulls is plugging of the lines leading to and from the distillation column and plugging of the Sweco vibrating separator which partially dewaters the stillage (fermented grain solids). Plugging due to hulls has even been experienced in the distillation columns themselves.

These plugging problems result in decreased efficiency due to time loss. Currently, no steps are being taken to remove hulls, but it is being considered for the future.

D. Agitation

The initial fermentor design called for 4" hollow drill stem as the agitator shaft material. It was quickly discovered that hollow shafting was not strong enough to handle the torque since two of the shafts twisted off. A lack of agitation resulted in accumulation of high concentrations of carbon dioxide in the beer, probably resulting in decreased yields. Lack of agitation also caused settling of solid material in the fermentor which caused line plugging to the distillation columns, inconsistent feed rates to the distillation columns and increased loss of ethanol in the stillage.

This problem was alleviated by replacing the hollow shafts with solid shafts.

E. Contamination

By far the most detrimental problem with the fermentation stage is the presence of.extraneous bacteria both before and after the cooking stage.

When barley was first used the temperature at the time of grain addition was 120° F. since this was approaching the maximum recommended temperature for beta-glucanase, an enzyme used to reduce vicosity. Since grain addition is a slow procedure fermentors may be held at 120° F. for 18-24 hours. Bacteria found associated with barley (and probably wheat also) grew rapidly at this temperature. The bacteria that caused the major problem appeared to be of the genus Clostridium by microscopic examination and preliminary laboratory analysis. Some of these bacteria are known to produce hydrogen, a burnable gas, when growing on starch at PH 4.0 - 5.0. On two occasions, hydrogen productio- proceeded rapidly enough to allow accumulation of enough gas to cause an explosion causing extensive damage. Analysis of headspace gas by gas chromatography revealed that a 50% hydrogen, 50% carbon dioxide atmosphere was present. For obvious reasons this condition has been eliminated by adding grain at 160-170° F. above the maximum growth temperature of Clostridium.

The other contamination problem, contamination after cooking, is a much more difficult problem. Unwanted microorganisms are present in every batch to date. These organisms grow generally at a faster rate than yeast, consequently, the number of bacteria increase more rapidly than do yeast. These bacteria compete with yeast for available carbohydrates and other nutrients. So when these bacterial populations increase they increase at the expense of glucose meant for conversion by yeast to ethanol. The most common contaminating organisms produce organic acids anaerobically from glucose, so not only is the yield of ethanol per bushel of grain decreased, but the PH of the beer decreases requiring PH adjustment with sodium hydroxide. This increases labor and materials expense.

Yield decreases up to 50% have been experienced due to contamination.

There are many possible sources of contamination in the present system. The tank design allows areas for build-up of solids which harbor bacteria. Currently, there is no way available to wash and clean the tanks efficiently.

Another source of contamination is a lack of airtight seals in key areas like around agitator shafts and man holes. Airborne contaminants are not as critical a problem as dripping of contaminated liquid into these openings due to condensation or water pools on top of fermentors.

One of the largest sources of contamination as discussed previously, is grain lump break-down during or just before fermentation. The release of large numbers of bacteria results in more carryover bacteria to cause problems in the next batch.

To aid in alleviating the problem all areas in the fermentor that allow deposition of solids are currently being sealed. Also, measures are being taken to eliminate milled grain lumping by changing the grain addition site and modifying the agitator blades to mechanically shear the lumps. Another step being taken is to use a viscosity reducing enzyme (beta glucanase) that is active at temperatures high enough to inhibit the growth of contaminating bacteria.

Low levels of penicillin will be added to each batch to aid in controlling any bacteria that are present even after other precautions have been taken.

Finally, a spray cleaner device is being purchased to thoroughly clean each tank of any residue after each batch. A dilute sodium hydroxide wash followed by a phosphoric acid wash will be used as a cleaning solution.

All these steps in combination should satisfactorily control infection by undesirable microbes.

HEAT EXCHANGER

After fermentation, the slurry goes through a heat exchanger before it goes through the stripper column. The mash coming out of the stripper column goes through the heat exchanger the opposite way, flow and counter flow. From here it goes to the sweco separator, where the stillage is extracted from the mash. What is left is called stillage, which is fed to the dairy and stock cattle.

The heat exchanger consists of 2" and 4" steel pipe, schedule 40. The heat exchanger is 750 feet long in 10 lengths of 75 feet each. They are connected together with pipe fittings and unions. The pipe came in 20 feet and 40 feet lengths and were welded, fit and put in place by the employees of A.E. Montana. The 2" pipe fits inside the 4" pipe. Every 2 feet there are three (3) pieces of metal 1/8" x 1x6" welded on the pipe, evenly divided around the pipe to center the pipe inside the 4" pipe. One inch from the opposite end of the flow is a 30° angle which gives the material a swirl effect for better heat exchange.

The idea of the heat exchanger is to save energy. We take the fermented mash from the tank, which is 85° F and with a positive displacement pump we put it through the inside portion of the heat exchanger to the stripper column. The material coming from the stripper column comes out at approximately 200° F. going through another displacement pump through the outside portion of the heat exchanger. That way the fermented mash is heated up and the stillage is cooled off.

MARKET OUTLOOK

July 9, 1981 I was employed by A.E. Montana as an outside salesman to sell ethanol within the state of Montana.
I have been associated with the petroleum business all during my working life with the last 20 years as General Manager of the Gallatin farmers Company in Belgrade. My association with the cooperative field gave me the opportunity to become known statewide, also giving me a greater knowledge of the petroleum business statewide.

When ethanol was first introduced as an alternative fuel there was a lot of interest and those that had their own transport trucks took advantage of this interest and trucked ethanol into Montana either from the west coast or the east, as that was the only supply at that time. As the demand increased through making an alternative fuel and its many other uses, the manufacturer's raised their prices where it was no longer profitable for them to truck it into Montana. Those that were using ethanol soon were priced out of the ethanol business. However, there was still a lot of interest in an alternative fuel and plans were being made by groups to start manufacturing ethanol within the state.

The Montana Legislature and federal legislators also recognized the need for an alternative fuel, so they passed legislation at the federal level of 4¢ a gallon tax forgiveness and the Montana legislature passed a 7¢ a gallon tax forgiveness on the fuel to be added to the alcohol to make gasohol.

With this legislation the interested groups started to work again and we have two ethanol plants in Montana with more on the drawing boards.

My first contacts were made in Missoula, Montana at Western Montana Cooperative. It was one of the companies that was trucking ethanol in from the west coast and had a market of 17,000 gallons a month which made over 1,500,000 gallons of gasohol annually.

Western Montana is buying ethanol from A.E. Montana and will again distribute ethanol in Missoula and surrounding areas plus delivering gasohol from Kalispell south to Polson, Ronan, Hamilton, Seeley Lake and any other accounts in the area that can be developed.

I also called on Hi Noon - Bill Nooney, President, who has a Phillips 66 bulk plant in Missoula and serves most of the 7-11 convenience stores in the state. Mr. Nooney was reluctant at this time to change any of the stores over as he had put diesel fuel in place of premium gas, and it would take additional capital to install tanks and pumps. He is in the process of installing a 12,000 gallon tank in Bozeman at a new convenience store to put in gasohol at that location.

My next stop was Butte, as Waite Oil Co. had indicated an interest in gasohol. When I contacted Mr. Waite he was interested in all the facts of making alcohol and all the necessary preparation at his plant and the service station to start serving the public. I have made several contacts since. Mr. Waite has been ill for the past month, however, I feel that prospects are good for the future.

Town Pump and Affiliates head office is located in Butte. I was referred to Jim Kenneally, Field Representative, and was informed they had been very interested and had done a lot of research on it prior to any plants being built in Montana. Due to not being able to get premium gasoline they had made a lot of changes in their stations and they could not at this time see where it would be economical for them to put in additional tanks and pumps to handle gasohol, however, they would take it up with their planning committee for additional study. The last time I talked to Mr. Kenneally, he indicated to me they were considering putting gasohol in 2 of their 60 stations in the near future.

We also have J.B. McBride Distributing Inc., Exxon Petroleum products who have consolidated with John Fagan, former Texaco distributor. They were to have a meeting and would advise us of their interest. It is my opinion they will buy full transport loads of alcohol and blend their product as they own 2 bulk plants. They will also be in a position to sell other customers and companies.

I called on Conoco and Cenex in Butte and they did not show any interest at this time.

Farmers Union Grain Terminal Association in Three Forks owns a service station and sells Cenex products. They are having a meeting the 28th of November and will at that time make a decision as to how and when they will start selling gasohol. Ted Schlepp, the manager of this station, is very much in favor of gasohol and says if nothing else he will give it a try in a small tank he is not using at this time.

I have called on every distributor in Bozeman. The most interest shown at this time is with Dave Rutledge, Conoco distributor, and he is considering putting gasohol in one of his Convenient Marts in a very good location on Main street in Bozeman.

I have had considerable resistance in Bozeman due to the dealers having to make additional investment to handle gasohol. Most stations have one product twin dispensers; also the State now requires all stations to have full price computers instead of the old half price kind. In many cases this will cost the dealer or owner 5 to 7,000 dollars per station.

We have the Conoco Travel station, owned by John and Betty Tagert, located at the 4 Corners, that have indicated they will start buying ethanol as soon as proper arrangements can be made. This account is supplied by Dave Rutledge, which also gives us another chance of selling all the Conoco stations.

About three-quarters of a mile south of the 4 Corners is a small serve-yourself station that is run by Mrs. Cox and her son. They have been in business at this location for several years as was her brother, so they have quite a following. To look at this station you would never guess they have large tanks and buy their products in tanker loads. The name of their station is the Wheel Inn and they will market gasohol.

West Yellowstone has only a couple of stations that stay open year round. Whitman's Conoco station keeps open the year round; Larry Whitman is the son of the Whitman family who started the station years ago. He is a lawyer in West and oversees and hires help to operate the station. He is very much interested in gasohol and plans on buying his own transport this spring and hopes to be in the gasohol business.

The Conoco Travel Shop at Big Sky is owned and operated by Dave Rutledge of Bozeman. He has a young lady as manager of the station. She is very interested in getting into the gasohol business and has done quite a little research on it. She is interested in the increase in octane and the savings to the customer she would be able to give by having a premium gasoline.

Curtiss Arthun, Exxon Jobber in Livingston, is going to put gasohol in all of his stations in Livingston, however, he happens to be the uncle of the Doig brothers who own and operate another alcohol plant at Ringling, Montana and he will purchase his supplies from them.

McLeod Mercantile of Norris, is an old time Texaco Jobber with about 13 stations and is now a Conoco Jobber. He has purchased 3 part loads of ethanol from us and is putting it in his stations as circumstances permit.

Montana States Petroleum, Billings, known better as Bair's Truck Stop, has been selling premium unleaded in their Belgrade station. They report the acceptance is very good. They also picked up a transport load of ethanol for Billings where they will either sell ethanol or blend for use as gasohol. We expect this to be one of our largest accounts because, by handling straight ethanol it gives the dealers a break and makes it readily available and close at hand for a large marketing area around Billings.

Kenco Refining Co. at Wolf Point, who has been shipping ethanol in from the east to date, has purchased 2 transport loads from us. This will continue to be a good account because they already have their gasohol business established. They report very good acceptance in that area.

We also have contacted Super America, a division of Ashland Oil Inc., by Letter and to date we have not heard from them.

We contacted the Cenex Refinery at Laurel. They are shipping ethanol in from the east. So far we have not been able to sell them because they market their products in other states and our prices would only be attractive in Montana due to the 7¢ state tax forgiveness. They tell us that most of their gasohol sales are in other states. This is understandable because, until recently, there were no ethanol manufacturing plants in Montana.

We also have been in contact with Flying J. Inc. of Brigham City, Utah, who own and operate the small refinery at Cutbank, Montana. They are a potential user of ethanol as an octane improver and also could use ethanol and sell it from their plant.

After the first of the year, the Phillips Refinery which was just sold to Simmons, the deal to be completed January 1, 1982, will be a prospect for ethanol as an octane booster and blend for gasohol.

It seems the most resistance that I have encountered is in the additional book work and the dealers not making enough money to make additional improvements to their stations.

It should also be mentioned that the largest users of ethanol are shaping up to be refineries, like the Kenco outfit in Wolf Point where ethanol is used not as a replacement for gasoline, but as an octane boosting agent.

SALES REPORT

During November 22,800 gallons of alcohol were sold for a total of $43,540. Stillage sales were at $1460.00; which represents sale of 76 tons.

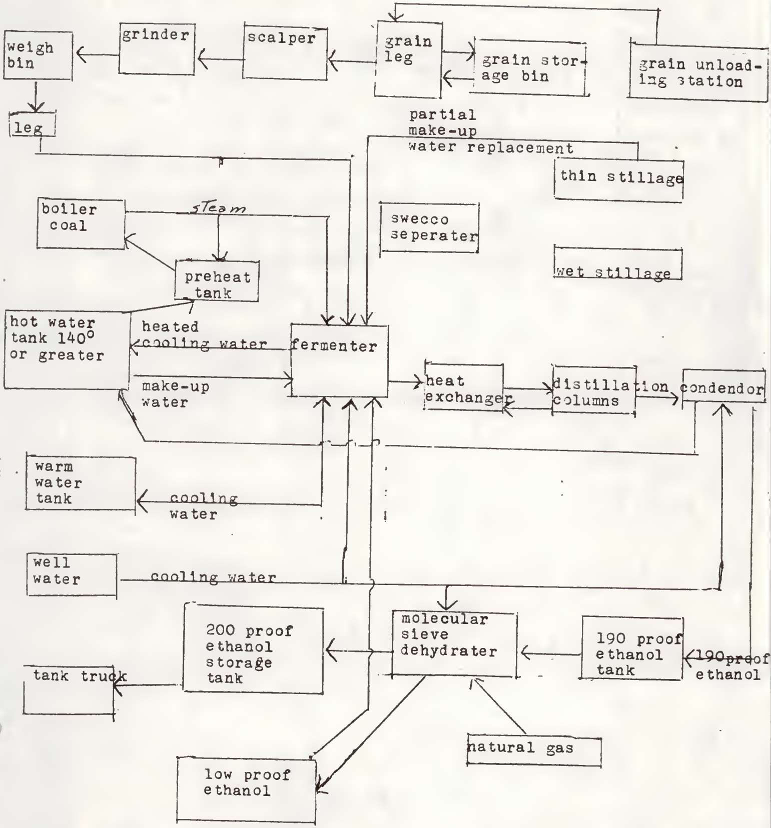
Stillage sales are expected to rise to 450 tons in January once a delivery system is established. This target figure is contingent upon the plants production. Management's experience has been that demand will exceed production as long as quality control and consistency of product availability is maintained. To date stillage production has been spread out in trial form to over 20 local cattle and dairy operations many of which would like to stay with the feed product.

Alcohol sales should rise to a 30,000 gallon figure in January. New outlets in Helena, Butte and Bozeman are coming on line at this time. These outlets, in addition to established outlets in Wolf Point, Billings, Missoula, Belgrade and Harrison represent market for over half of A.E. Montana's full monthly production potential. The Billings outlet alone has indicated an ability to increase its monthly purchases to as high as 60,000 gallons, A.E. Montana's full production level.

The overall picture looks favorable for both ethanol and stillage sales. Stillage does require a transportation system, the mechanics for which are being worked out now. Once A.E. Montana reaches full production in a projected six months, both alcohol and stillage sales should be at production levels.

457-811
Engineer's
final

EXHIBIT 1



GRAIN HANDLING SYSTEM

Grain trucks pass over a certified scale to an unloading hopper. Dumped grain travels to a 12,000 bushel grain storage bin via a 65 ft. grain leg #1.

When milling the grain passes out of the storage bin back to the grain leg #1 and into a scalper which removes foreign material. The grain gravity feeds into a hopper bottom storage area above a Poscamp roller mill. The grain flow is controlled through the roller mill.

Milled grain is augered out of the bottom of the roller mill to grain leg #2 (60ft.). From there the milled grain is dumped into a hopper bottom storage tank mounted on load cells for weighing.

When milled grain is added to fermenters it passes out of the hopper bottom bin to grain leg #2 via an auger. The leg is connected to each fermenter.

See Figure 2.

Separate [illegible]

EXHIBIT 2

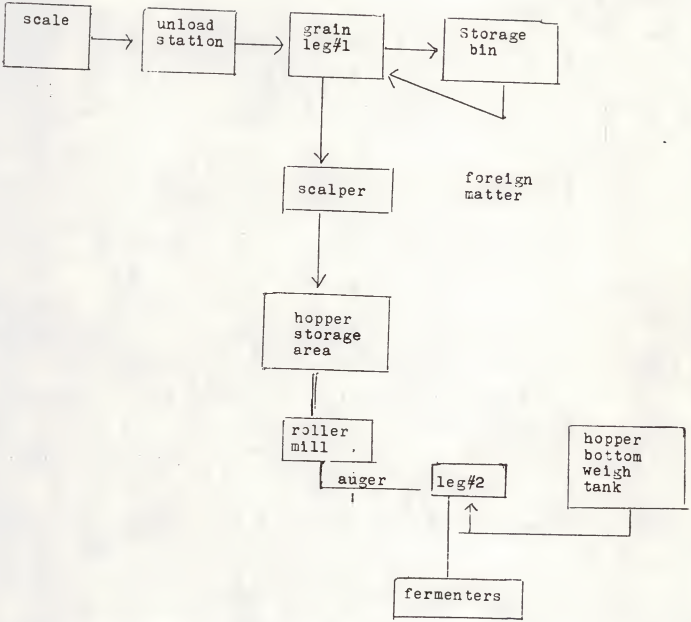


Figure2. Diagrammatic Representation of the Grain Handling System.

Exhibit 3

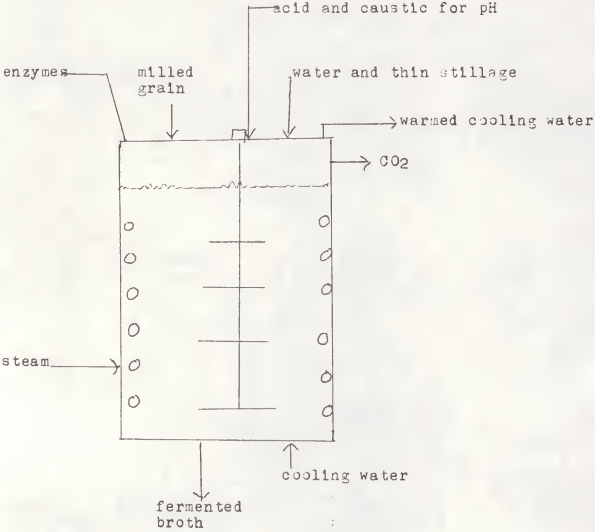


Figure 3. Diagram of The Fermenter/Cooker

DISTILLATION AND DEHYDRATION

After the medium has fermented the beer is pumped through a heat exchanger into the stripper column where the beer is heated with steam. The enriched alcohol-water vapor passes into and through a rectifying and finishing column. Then the vapor passes through a condenser to yield 138-190 proof ethanol in a liquid state. This material travels through a meter and into a storage tank. The beer after the alcohol is removed passes back through the heat exchanger at 190°-200°F; and preheats the incoming unstripped beer.

The 3 columns are 26 feet tall and 18" in diameter. They were purchased from Schroeder Brothers, Campo, Colorado.

190 proof ethanol has been produced through the columns at approximately 70 gallons per hour with less than 0.1% ethanol remaining in the waste liquid.

The dehydration of 190 proof ethanol to anhydrous 200 proof is accomplished by passing the 190 proof alcohol through molecular sieve. The molecular sieve dehydrator was also purchased from Schroeder Brothers. The column contains 7500 pounds of molecular sieve purchased from Grace and Co.

190 proof ethanol is pumped into the dehydrator at a rate of 10gpm. The void volumn is approximately 800 gallons before 200 proof begins to come out. 1300-1400 gallons of 200 proof are produced before the molecular sieve is saturated with water. Before complete saturation accurs approximately 150 gallons of lower proof alcohol is produced which is pumped either into the 190 proof holding tank if the alcohol is between 188-197 proof, or into a fermenter being being distilled if the proof is less than 188.

EXHIBIT 4

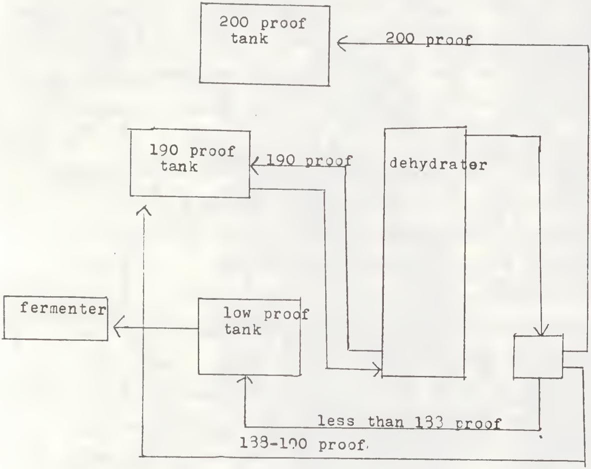


Figure 4 Diagram of Dehydration Scheme for 190 Proof Ethanol.

INPUT ENERGY AND HEAT RECOVERY SYSTEMS

1. Energy Inputs
    - a) coil for boiler
    - b) natural gas for dehydrator
    - c) electricily - motors, lights, etc.

2. Energy Recovery Systems
    - a) Heat exchanger - column waste line preheats incoming beer line
    - b) All water greater than 130°F is stored in hot water tank and used for fermenter make-up water of as feed water for boiler preheat feedwater tank.

        1) Source - distillation column condenser and fermentor cooling water from hot fermenters.

    - c) Warm water - greater than 85° but less than 135° - stored in a warm water tank. Used if necessary in fermenter make-up water, pumped through hot fermenters as cooling water recycled into the hot water or warm water tank.

    - d) Pre-Heated Boiler Feed Tank - Water from the hot water tank is added to a 500 gallon tank and the temperature raised to 190°-200°F by steam injection for use as feed water to the boiler.

        See Figure 5

EXHIBIT 5

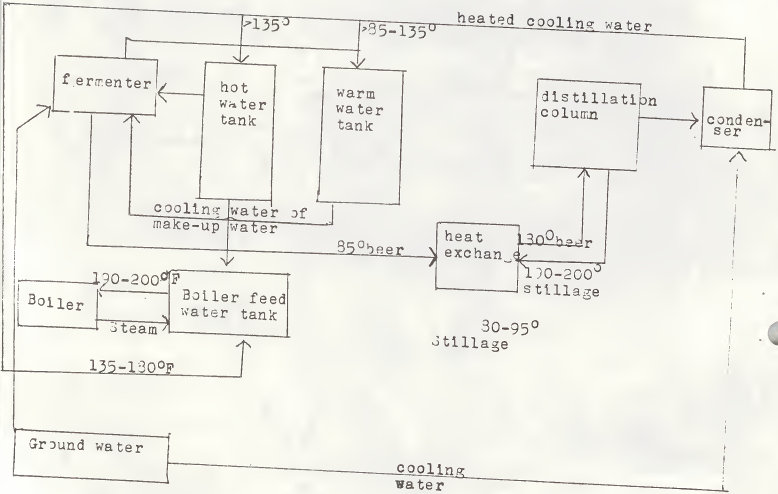


Figure 5. Diagram of Heat Recovery Systems

WET STILLAGE HANDLING SYSTEM

The solids are seperated from the liquid portion of stillage in a vibrating screen seperator. The solids are stored on a concrete slab and sold as a high protein dairy cattle suppliment. The liquid thin stillage is stored in a tank and spread over pasture land when the tank is filled.

PUMPING AND HANDLING

A variety of types and sizes of pumps are used depending on the required output and the nature of the material being pumped. Alcohol is pumped using pumps with sparkless motors and wiring run in conduit. An explosion proof room houses the columns and alcohol handling equipment.

190 and 200 proof alcohol is stored in fiber-glass-lined steel tanks that have locks on the outlet valves. The alcohol is denatured with gasoline by addition of drums to the holding tank.

CONTROL SYSTEMS

54 electronic sensor probes throughout the system monitor conditions at every step. Alarms are sounded when conditions exits that are outside the designed control parameters. A lighted panel board with flashing lights at the potential trouble areas aid operators in quickly diagnosing the source of the alarm condition so that appropriate measures can be taken to correct the problem. Operators have been educated as to what areas to closely monitor and what to do to correct alarm conditions.

CONSTRUCTION PHASE

Areas or Phases of Construction

1. Metal Building
2. Gfain System
3. Tank Fabrication and Plumbing
4. Boiler Installation
5. Wiring
6. Control Panel Fabrication and Wiring
7. Storage tank Setting and Plumbing
8. Disstillatior Column Installation
9. Water System Installation
10. Dehydrator Installation
11. Stillage Handling (including Seveco Vibrating shaker installation)
12. Miscillaneous (driveway, miscillaneous carpentry and concrete work)

CHANGES FROM ORIGINAL PLAN

OPERATING PROCEEDURE AND EXPERIENCES IN ETHANOL PRODUCTION

Using white wheat fermenter yields have approached 10% v/u of ethanol after 4 days fermentation. The white wheat mixture becomes sonewhat more viscous upon heating but addition of the starch-degrading alpha amylase (Take-Therm) controls the viscosity very well. Conversion of starch has been very efficient using tako-therm, however a small amount of residual starch has been detected in the beer after the fermentation is complete.

Agitation is very violent with the installed system and has worked well, however with the current design a problem with agitator shaft strength has developed. Used oil well drillstem pipe was used as agitator shaft material and one shaft has twisted off so a solid shaft section was added to reinforce the problem area.

The distillation columns have worked well and are very efficient at an output rate of approximately 70 gallons per minute pf 190 proof ethanol. However currently the column requires close operator monitoring due to fluctuations in steam presure which change parameters within the column.

Ethanol measurements in thin stillage have ranged from undetectable to less than 0.1% based on liquid chromatographic analysis.

The molecular sieve dehydrator has performed exceptionally well and has been very trouble free. Approximately 1300 gallon of anhydrous ethanol can be produced until the molecular sieve is saturated with water. Pump down and drying time takes approximately 6-3 hours. So the turn around time is 10-12 hours resulting in 2500-3000 gallons of anhydrous ethanol produced per day.

BUSINESS ORGANIZATION AND FINANCING

The ethanol plant was financed primarily through selling of stock, personal, and bank loans primarily. Private investors have added a substantial portion of the capitol and signed loan agreements with lending institution for additional capitol. Some grant money has been procured with more being applied for currently.

The corporation has a 6 man board of directors each having a finanical holding. Regular meetings are held to review current status of construction and production of ethanol.

Investers have been supplied recently with a detailed financial statement that will be updated when the cash flow situation improves with product sales.

The management consists of the president, Bruce Kania, a plant manager, plant foremen, two engineers, a biochemist and plant operators. Each employee also serves as an operator either full-time or when needed to replace an absent operator.

PLANT PERFORMANCE

To date white wheat has been used as the fermented grain. Four batches have been run completely through the plant with yields varying from 2.26-3.1 gallons of ethanol per bushel of wheat. Fermenter yields have been approxmately 2500-3000 gallons of ethanol per batch.

Apparently the distillation columns have been very efficient with alcohol levels in the thin stillage averaging less than 0.1% ethanol.

The molecular sieve dehydrator has been operating well with a through put of approximately 2600 gallons of 200 proof ethanol per hours. After saturation of the molecular sieve with water ethanol of less than 197 proof comes off when the column is heated for drying. This lower proof ethanol is pumped into a fermenter being distilled so as to recover the alcohol.

The energy inputs have been described previously but as yet the exact amount of energy used per gallon of ethanol produced has not been calculated since much of the equipment operation (especially the boiler) is still being optimized and the operation thoroughly learned by the operators. More data should be available in 3-6 months.

The same holds for water usage. New ways to conserve and recycle water are being identified and the operators are becoming familiar with/these conservation measures. The water usage should decrease after the system has been thoroughly tested.

Stillage and thin stillage production have been 20 tons and 20,000 gallons per day respectively. The stillage has been given to local dairy farmers as a protein supplement and no market has been found to date for thin stillage.

MARKET AND PRICING FOR PRODUCTS.

We are still in early phases of developing a steady market for the ethanol produced, but most interest has been expressed by regional bulk gasoline plants. The ethanol selling price is between $1.90 and $2.05 per gallon depending on the quantity

2. Plant construction began in September of 1980. Since then approximately 1,960 man-days of labor have been expended in bringing the facility to an operating stage.

The summer and fall of 1980 was spent arranging corporate matters, seeking financing, applying for grants, landscaping the premises, laying the foundation, disigning the plant and erecting the building. Three individuals took part in this phase, which lasted through December of the year.

Minimal work was completed through January and February since financing had not happened. Money and commitments came through in March, at which time a full crew of ten persons were put to work, initially on tank construction. The cooking coils and agitator system went in next, along with the plumbing. A panel control system was also being worked on through this period.

As the weather warmed up the grain system and well were put in by independant contractors. Some components of the grain system, like the scale, were put in place by company personnel. Wiring work began in April. Personnel training also took place through this period.

The heat exchange system was installed during May. Storage tanks and the associated plumbing came in during May, June and July. The distillation columns were also installed in July.

A dehydrator was installed late in August early September and since then the plant has been in operation on about a 50% basis. The plant had tested and produced 190° alcohol in July.

3. The most significant change in original plans was that of the gas to coal fired boiler. Dramatic increases in price of natural gas instigated this change.

The coal or sawdust fired low pressure system was about $50,000 more expensive than a gas system would have been. The company expects to recoup this price differential with in a three year period.

Currently it appears that coal quality and draft controls on the boiler greatly influence boiler performance. At this time the boiler is operating at around 50% of optimum, pending installation of draft controls. Use of only proper grade stoker coal will also bring this figure up.

5. Costs of the project are outlined in the enclosed financial sheet. D,N.R.C. grant money was used to pay for tank steel and part of the grain system. Operating costs are projected in exhibit 1. A., a monthly cash flow projection sheet.

9. The plant has attracted over 1,000 visitors to date. Over 400 people attented the open house. There appears to be strong community support, and interest in the concept.

On the other hand it is apparent that to maintain good community relationships an effective method of handling the thin stillage plant byproduct has to be developed. As it can cause noxious odors if simply spread over ground. Currently plant and university personnel are studing several alternatives including a centrifuge system, a dehydration system, a pond evaporation system, and possibly, a system to market the thin stillage condensed to about 9% solids as a feed supplement. Analysis completed at MSU indicates the solids are 65% protein, so a market approach may be realistic.

457-811

OPERATING PLAN FORECAST (Profit and Loss Projection)

		Month 1 July			Month 2 Aug			Month 3 Sept.			Month 4 Oc	
Revenue (sales)	Ind %	Estimate	Actual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate	Act
Ethanol		19,200			20,000			100,000			130,000	
Stillage					4,050			6,860			27,000	
[illegible]								12,500			12,500	
Loans												
Grants											28,300	
Stock Sales		75,000			75,000							
Total Revenue (sales)		94,200			99,050			119,360			197,800	
Cost of Sales 35¢ [illegible] 2.72 Bu Grain		34,500			—			87,300			160,450	
Phil Tolej		11,000			9,600			9,600			11,520	
Yeast, Enzymes 14¢ [illegible]												
[illegible] chemical [illegible]												
Total Cost of Sales		45500			9600			96900			171970	
Gross Profit		48700			89450			22,460			25,830	
Expenses												
Salary expense: Sales people, office and other		1400			1400			1400			1400	
Payroll Expenses (taxes, etc.)		11098			11098			11098			11093	
Outside Services		2,000			1000			500			200	
Supplies (office and operating)		250			200			200			200	
Repairs and Maintenance		600			800			800			800	
Advertising		3,000			2000			2000			1,000	
Car, Delivery and Travel		400			400			400			400	
Accounting and Legal		500			250			250			250	
Rent		150			75			75			75	
Telephone		140			140			140			140	
Utilities		1,000			1,500			4,000			4,700	
Insurance		250			950			950			950	
Taxes (real estate, etc)		50			50			50			50	
Interest		1,200						400				
Depreciation												
Other Expenses (specify each)												
Equipment		155,000			3,000			1,500			9,800	
Construction costs		15,500			2,000			1,000			500	
Loan payments		65,000										
[illegible] Inventory		3,000			750			7,700			7,700	
[illegible]		5,000						3,000				
[illegible]					2,000							
Banks [illegible]												
Miscellaneous (unspecified)												
Total Expenses		276038			29,613			40463			39263	
~~Net Profit~~ Cash Position		(227338)			59,837			(18,003)			(13433)	

SBA FORM 1099 (8-75) REF: SOP 60 10 1

Cumulative cash position (227,338) (167,501) (185,504) (198,937 ne of Business

Oct		Month 5 Nov			Month 6 Dec			Month 7 Jan			Month 8 Feb			Month 9 m
Actual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate
		130,000			96,000			130,000			130,000			130,000
		27,000			27,000			19,600			27,000			27,000
		12,500			12,500			12,500			12,500			12,500
		54,500			49,500									
								50,000						
		234,000			184,000			211,100			169,500			169,500
		84,000			58,000			32,000			145,280			84,000
		11,520			14,400			14,400			14,400			14,400
		95520			72400			46,400			159680			98400
		138480			111600			164700			9820			71,100
		1470			1470			1470			1470			1470
		11,500			11,500			11,500			11500			11500
		200			200			200			200			200
		200			200			200			200			200
		800			800			800			800			800
		1,000			500			500			500			500
		400			300			400			400			400
		250			250			250			250			250
		75			175			175			75			75
		145			145			145			145			145
		5,000			3,500			5000			5000			5000
		950			950			950			950			950
		50			50			50			50			50
		300			12500			8,200			200			200
		200			150			150			150			150
		7700			5300			7700			3243			5201
		3,000									7700			7700
					4500									
		33240			42490			37690			32,933			34891
		105,240			69,110			127010			(23,113)			36209
		(93 697)			(24,587)			102,423			79 310			115,519

OMB No. 100-R 0084

For Period Ending

		Month 10 April			Month 11 May			Month 12 June			July		Totals	
tual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate	Actual	%	Estimate	%	Actual	%
		130,000			130,000			130,000			130,000		1,405	2[illegible]
		27000			27000			27,000			27,000		272	510
		12500			12500			12500			12500		137	500
													14	300
													[illegible]	000
		169500			169500			169500			169500		2,156	510
		84,000			84,000			84,000			84,000		1,021	530
		14,400			14,400			14,400			14,400		168	440
		98400			98400			98400			98,400		1,189	970
		71,100			71,100			71,100			71,100		966	540
		1545			1545			1545			1545		19	130
		12130			12130			12150			12150		151	112
		200			200			200			200		5	5[illegible]
		200			200			200			200		2	650
		800			500			800			800		10	200
		500			500			500			500		13	000
		400			400			400			400		5	100
		250			250			250			250		3	300
		75			75			75			75		1	150
		145			145			150			150		1	875
		5000			5000			5000			5000		54	700
		950			950			950			950		12	350
		50			50			50			50			650
													1	600
		200			2,500			200			200		205	700
		150			700			150			150		20	150
		11,761						2,335			5292		92	8[illegible]
		7700			4800			4500			4500		77	3[illegible]
													13	000
													7	000
													4	500
		42,106			31495			29785			32,742		702	749
		28,994			39605			41315			38,358		263	731
		144,513			184,118			225,433			263,717			

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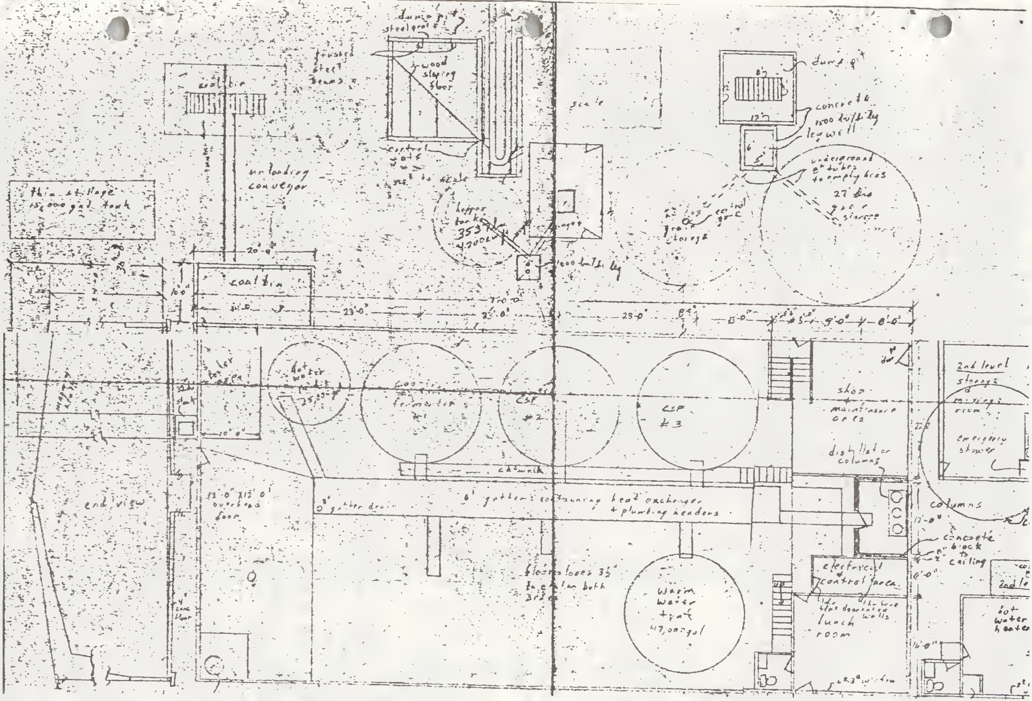
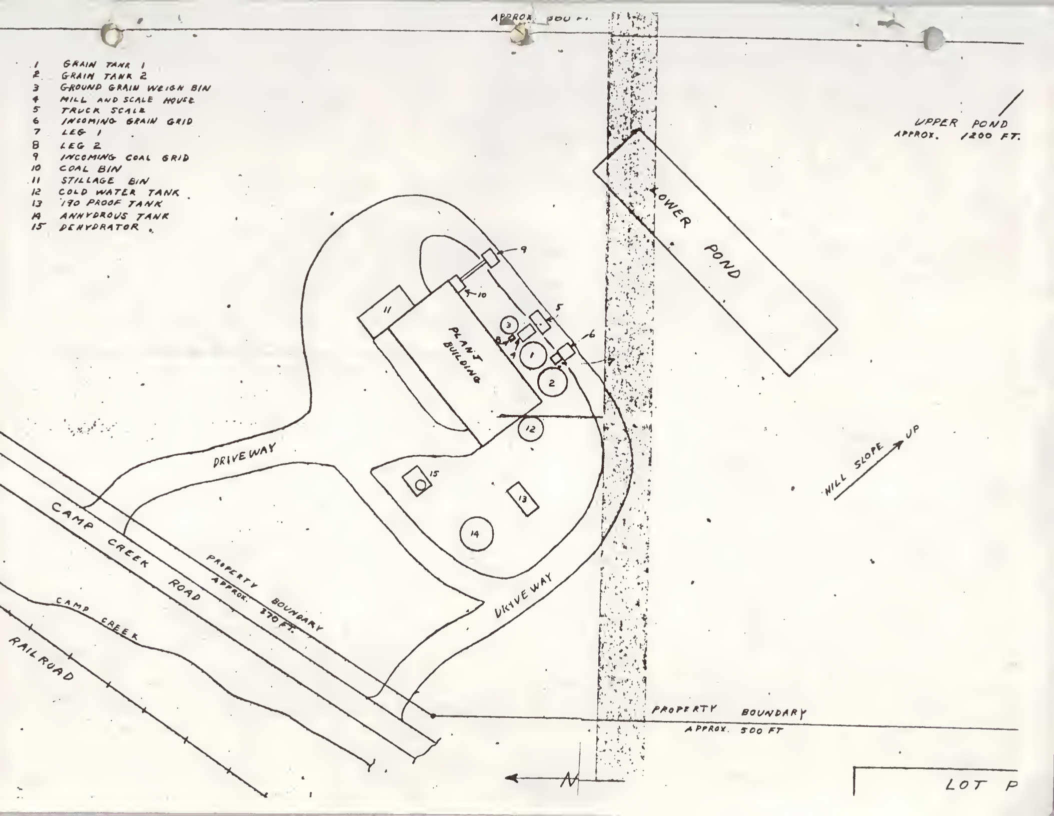

dump pit
steel grate
trussed steel beams
wood sloping floor
coal bin
control gate
next to scale
unloading conveyor
thin stillage 15,000 gal. tank
hopper tank 353 4,200
20'-0"
coal bin
10'-0"
23'-0"
23'-0"
1000 bu/hr leg
scale
dump pit
8'
12'
concrete
1500 bu/hr leg
leg well
underground tubes to empty bins
27' dia grain storage
grain storage
control gate
23'-0"
15'-0"
3'
9'-0"
8'-0"
boiler area
stack
10'-0"
hot water tank
cooling fermenter #1
CSF #2
CSF #3
catwalk
shop
maintenance area
2nd level storage & mixing room
emergency shower
distillation columns
columns
17'-0"
concrete block to ceiling
6'-0"
end view
12'-0" x 12'-0" overhead door
8" gutter drain
6' gutter containing heat exchanger + plumbing headers
floor slopes 3½
4" conc floor
warm water tank 47,000 gal
up
electrical control area
lunch room
16'-0"
hot water heater
2nd level


APPROX. 500 FT.
1 GRAIN TANK 1
2 GRAIN TANK 2
3 GROUND GRAIN WEIGH BIN
4 MILL AND SCALE HOUSE
5 TRUCK SCALE
6 INCOMING GRAIN GRID
7 LEG 1
8 LEG 2
9 INCOMING COAL GRID
10 COAL BIN
11 STILLAGE BIN
12 COLD WATER TANK
13 190 PROOF TANK
14 ANHYDROUS TANK
15 DEHYDRATOR
UPPER POND
APPROX. 1200 FT.
LOWER POND
PLANT BUILDING
DRIVEWAY
DRIVEWAY
CAMP CREEK ROAD
CAMP CREEK
RAILROAD
PROPERTY BOUNDARY
APPROX. 370 FT.
PROPERTY BOUNDARY
APPROX. 500 FT
HILL SLOPE UP
N
LOT P

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